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ABSTRACT

New technologies will produce a radical restructuring of work, including a devaluation of current work skills and the creation of new ones at an ever-increasing rate. The robotics industry provides a prototype for the impact of technology on society, and a context for examining the relevancy of schooling in preparing individuals to function within that society. By examining the context in which education for robotics is occurring, the expanding role of education and the growing variety of institutions providing education and training becomes evident. Five sectors of society provide education-related services pertinent to robotics and the other high technologies: (1) government; (2) education; (3) business/industry; (4) labor; and (5) mass media. Each sector has the primary responsibility for only certain aspects of the educating process, although those functions do overlap. The occupations that are emerging in response to high tech industry needs call for new, essential skills which focus on process rather than subject matter content: critical thinking, problem-solving, creativity, application, synthesis, decision-making, communication, and evaluation and analysis. Those individuals who have the requisite knowledge and skills, with the acknowledgement that they will need lifelong retooling, can look forward to a productive place in our society. As a new technology, as an information technology, as an integration of several technologies, and as a major growth industry, robotics can help lead the way for making connections between education, technology, and employment. (JB)

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BRIDGING THE GAP IN ROBOTICS EDUCATION

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BRIDGING THE GAP IN ROBOTICS EDUCATION

It has now been confirmed that the nation has moved from a production-based economy to a service-based economy. While only 20% of U.S. workers are now involved with the manufacturing of products, 65% are providing informational services. The most essential resources identified in this service-based economy is educated people.

The rapid movement toward the automated factory is representative of the impact the new technologies are having on our workforce. It will affect American jobs and jobholders on an unprecedented scale. A radical restructuring of work, including a devaluation of current work skills and the creation of new ones at an ever-increasing rate can be expected. The fundamental changes occurring in the workplace will make it necessary for employers to retrain huge numbers of workers. The Nation's education system will have to become more responsive to the demands of the workplace in preparing future workers for functioning in a high tech information society. It is estimated that 45% of all jobs will be affected by automation by the year 2000.

In the summer of 1982, a Congressional Budget Office report stated that by 1985 automation would eliminate 200,000 auto production jobs. It would reduce the steel work force by 2 to 3% through 1990. By the year 2000, industrial robots could eliminate 7 million jobs. On the other hand, by the 1990s, 14.5 million new jobs are expected to be available, of which 1,500,000 are for industrial robot production technicians.[1] (See Figure 1) The nature of those evolving occupations make very evident this is not an unskilled or semi-skilled workforce we are talking about. There

are also other indicators that we may already have a surplus of robot technicians.

Figure 1

NEW OCCUPATIONS FORECAST FOR THE 1990s

Occupation	Available Jobs
Industrial Laser Process Technician	2,500,000
Battery Technician	2,500,000
Housing Rehabilitation Technician	1,750,000
Industrial Robot Production Technician	1,500,000
Energy Technician	1,500,000
Hazardous Waste Management Technician	1,500,000
Paramedic	1,300,000
Geriatric Social Worker	1,000,000
Materials Utilization Technician	500,000
Holographic Inspection Specialist	200,000
Bionic-Electronic Technician	200,000
Genetic Engineering Technician	150,000
Total Jobs Forecast	14,500,000

More about what the future might hold--by the year 2000 the factory assembly line will be a thing of the past. Japan will continue to have the largest robot population with over 11,000,000 by the turn of the century. In the United States, big business will grow even larger, dominating the markets of the new technologies and services. General Motors will make small, fuel-cell powered cars for local travel and buses for mass transit in congested urban areas. While GM will remain profitable for

many years, by the year 2010 it could vanish from the leading ranks of corporate conglomerations.[2]

What else might we anticipate as a result of robotics and the other new technologies? We can anticipate that the need for workers will dwindle as machines take over more and more of the work of humans. There will be a restructuring of the work week, which is likely to be reduced from five days to four to accommodate the reduced need for workers. Such a change has not occurred in almost a century. There will be an adjustment in compensation for work. Hourly wage is likely to be eliminated and replaced by salaried compensation. High tech jobs can be expected to increase by 50% by the end of this decade. The government will reassess and take measures to address the social impact of the high technologies, which so far it has grossly underestimated. The manufacturing industries will become increasingly service oriented. The information/service economy will become even more highly skilled and filled with knowledge workers. The role of education in preparing the workers of the future and keeping the knowledge and skills of the current workforce up-to-date will expand dramatically.

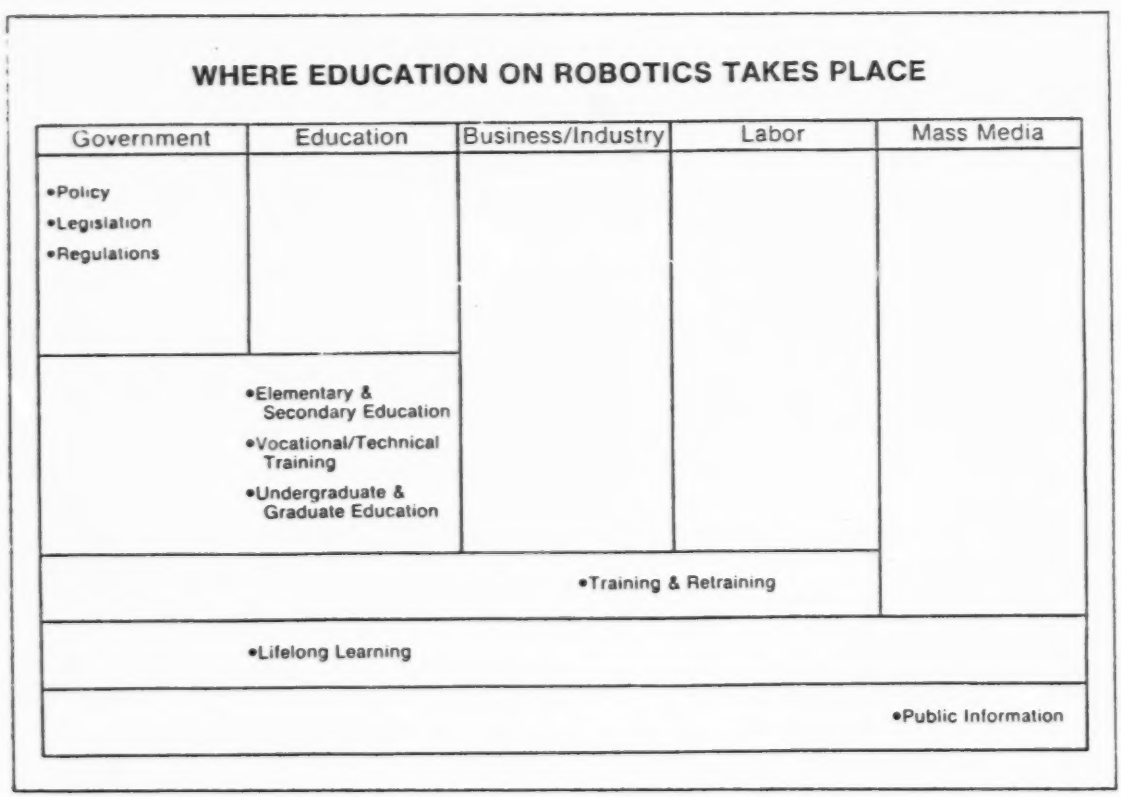
The Education Picture

By looking at where education for robotics is taking place, the expanding role of education and the growing variety of institutions providing education and training becomes evident. Technical skills development at the postsecondary level is not the only dimension of education for robotics. Robotics education actually begins in elementary school where learning concentrates on the development of the basic skills and other cognitive learning skills germane to robot technology. In high school

these skills are further developed and conscious preparation for entering the workforce begins. But schools are not the only places where education and training occur.

Five sectors of society provide education-related services pertinent to robotics and the other high technologies. The five sectors are: (1) government, (2) education, (3) business/industry, (4) labor, and (5) mass media. Each sector has primary responsibility for only certain aspects of the educating process, although those functions do overlap. (See Figure 2)

Figure 2



Government. The government, federal, state, and local, is a major force in providing education and training pertinent to robotics. Its primary functions revolve around public policy, legislation, and regulations. Implicit is the support for educational activities provided as a result of legislative mandates. Current legislation relevant to this discussion include the new job training partnership act and the innumerable mathematics and science education bills now being considered by Congress. In addition are government reports - many of you are probably aware of the two Congressional reports on robotics that came out in 1982--one from the Office of Technology Assessment, Exploratory Workshop On The Social Impacts of Robotics; and the other from the Joint Economic Committee Report, Robotics and the Economy. In addition the National Science Foundation has established an area on robotics research.

Education. The primary providers of educational services are public, private, and proprietary education institutions. Primary responsibilities focus on elementary and secondary education, vocational and technical education, and undergraduate and graduate education. Also, lifelong learning is frequently placed in this domain. Where robotics is concerned, postsecondary education has dominated the scene with most of the technical training being conducted by community colleges and professional training at universities and four-year institutions of higher learning. Elementary schools have yet to be recognized as sites for technological literacy to be addressed, with secondary schools not much better, even though the computer literacy bandwagon is riding high. Vocational and technical education for the most part continues to focus on technical skills development and is steadily eroding due in large part to technological obsolescence--unable to afford necessary capital investments in the new

technologies, and like elementary and secondary education, unable to maintain an updated teaching staff.

Business/Industry. The educational efforts of business and industry concentrate on work related training and education. Increasingly industry is finding it necessary to provide continuing education for its employees, as well as retraining for those displaced due to technological innovation. Today it is the largest educator of adults with its role as a provider of education and training expanding dramatically. Based on the New York Times Survey of Continuing Education conducted in 1981, 300 colleges may close during this decade as a result of the declining number of high school graduates, while 300 company-sponsored institutions of higher learning, which focus on highly specialized corporate needs, will begin operation.[3] As to robots, when they enter the workplace an initial orientation is frequently provided by the robot manufacturer, while the retraining of workers who will interact with the robots on a daily basis is left up to the user firms.

Labor. The majority of educational programs provided by organized labor falls into three categories: (1) college programs in labor studies; (2) apprenticeship programs; and (3) special programs of a continuing education nature on subjects such as labor law, collective bargaining techniques, and parliamentary procedures, as well as special programs on preapprenticeship training, basic skills education, and vocational exploration.[4] As the most vulnerable of the five sectors, labor is likely to become much more active as a provider and facilitator of education services as it strives to stave off the technological obsolescence and occupational displacement of its members.

Mass Media. The mass media is the primary provider of public information, an educational service frequently overlooked. Whether through entertainment, news broadcasting, special educational programming, or commercial advertising, the mass media educates the American public. Its influence is powerful, yet most of its educational effects, to date, appear to be non-intentional. Until the information revolution, much of its impact has been on a passive, inactive audience. As the application of information technologies becomes more interactive, the capacity for audience participation expands dramatically. The mass media has also influenced our perception of robots and robotics. We need only view the film Star Wars for one interpretation, or the news casting of the Robot VI Convention last year, which focused on televising the one humanoid display robot, over the nearly 100 industrial robots on exhibit.

Challenges Facing Public Education

For the robotics industry, the preparation and training of its knowledge workers has focused on postsecondary education provided by higher education. Another essential dimension of education important to the industry has been given inadequate attention, namely schooling, kindergarten through grade twelve. Schools provide the basic preparation for our workers of the future and should be cultivating a workforce responsive to our rapidly advancing technological society. Unfortunately, this does not seem to be happening. Rather than narrowing, the gap between education and technology continues to grow.

The issue is a complex one relating to our society in transition, which highlights the interrelatedness of technology, employment and education. The robotics industry provides a prototype for the impact of

technology on society, and a context for examining the relevancy of schooling in preparing individuals to function within that society.

Today's schools are faced with two critical questions: What are appropriate goals for education in the twenty-first centry?, and What do students entering a knowledge-intensive era need to learn? As schools strive to become technologically relevant, all sorts of challenges arise. The reexamination and redesign of preservice teacher education, teacher certification and the evaluation of student performance appear to be inevitable. In addition to the myriad of economic problems public schools are facing, educators are confronted with other critical issues brought on by the information revolution. Among them--introducing more technology into education, changing traditional delivery systems, and entering into new arrangements with business/industry and government.

While the traditional basics of reading, writing, and computation are being pursued with great vigor, and indeed are more necessary than ever, a reality we face is that even if all pupils were achieving to the fifth grade skill level, that level of achievement is insufficient for entry level employment in knowledge occupations. While computer literacy is rapidly emerging as a new basic skill, the need for a new set of essential skills, in addition to the basic skills, is becoming increasingly evident. The new essential skills focus on process rather than subject matter content. They include: (1) critical thinking, (2) problem solving, (3) creativity, (4) application, (5) synthesis, (6) decision making, (7) communication, and (8) evaluation and analysis--skills essential for functioning in a knowledge society.

Another concern is the renewed emphasis on science and mathematics education as the answer to the ills of American education. While the

shortage of good math and science teachers is real and needs to be remedied, placing the burden of responsibility for improving the quality of public education on these two areas does not get at the core of the problem. The resistance to viewing technology as a tool, as an enhancement to learning is a dilemma which needs resolution. Human-machine interface is a problem recognized by the manufacturing industry, it is also a problem educators face in schools.

Along with the other knowledge workers in our information society, lifelong learning will be an essential aspect of the work life of educators. Massive and compulsory inservice education will be necessary to maintain technological relevancy in our education enterprise. Faced with increasingly competitive and diverse institutions marketing education for profit, public schools can anticipate dramatic changes in structure and function. An immediate concern is for educators to become technologically relevant.

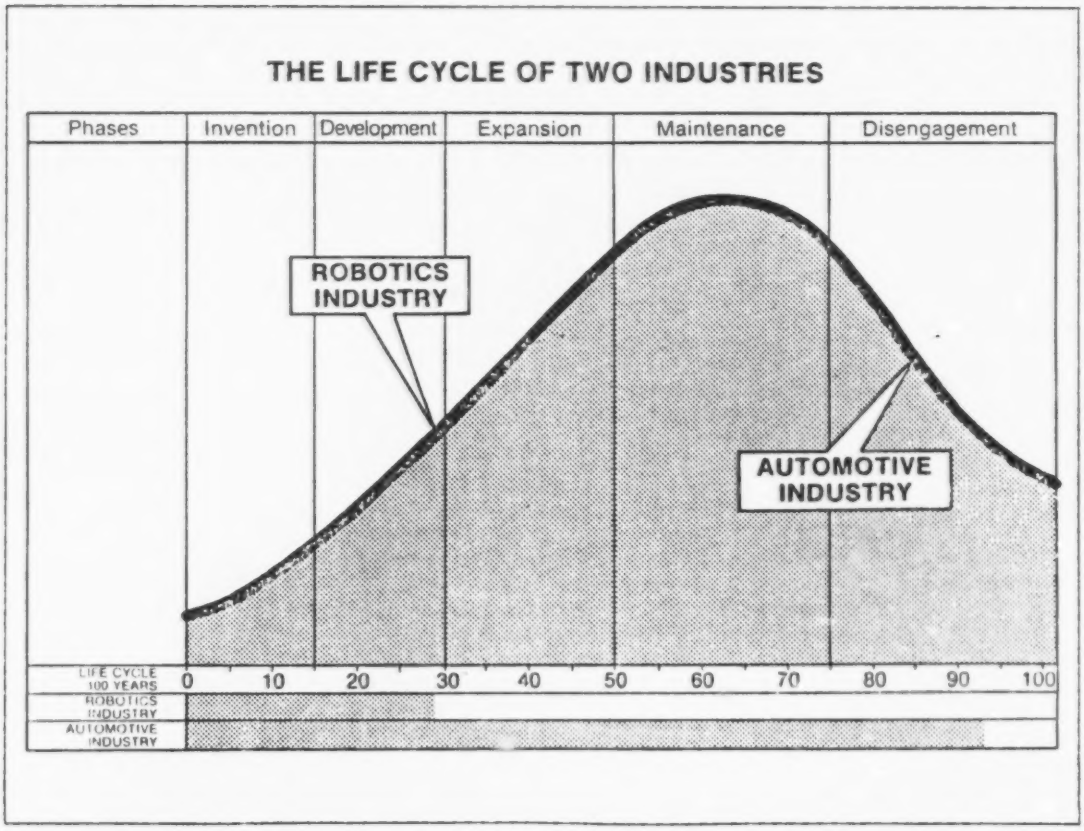
What robotics demands in the way of knowledge and skills is commensurate with those required of the other high technologies. Emphasis is on the new essential skills, supported by the traditional basics and integrated with the information technologies. In the not too distant future, robots may very well be used to perform many of the traditional teaching-related tasks--taking attendance, grading tests, giving assignments, reviewing materials, presenting material--while teachers are freed to develop the interpersonal relations skills and the process skills of their students. The capacity already exists for the computer to provide subject matter content.

High Tech Firms and Public Schools

To better understand the potential impact of robotics on our future and its relationship to our lives, it is helpful to compare the evolution of the automotive industry to that of the robotics industry. Interestingly, their development seems to parallel that of the human life span--but then both industries are the inventions of humans.

Plotted on a 100 year cycle, five phases of development emerge. (See Figure 3)

Figure 3



Phase I: Invention. The first phase highlights invention--the first automobile, the first robot--and includes the establishment of the first company to manufacture the new invention.

Phase II: Development. Development is the focus of the second phase when enterpreneurs in these new industries take action. Many new, small automobile/robot manufacturing firms appear. Competition is great. Many models are on the market. The robotics industry is at this phase.

Phase III: Expansion. Expansion marks the third phase. Changes occur in company organization as smaller firms are bought out. Fewer companies dominate more and more of the market. As consumer skepticism dwindles, so too does product cost as demand for the automobile/robot (product) mounts.

Phase IV: Maintenance. This fourth phase, akin to middle age, is characterized by maintenance of automobile/robot production and its share of the marketplace. A few major companies are manufacturing the majority of automobiles/robots for which there is a strong and constant consumer demand.

Phase V: Disengagement. In this fifth phase, as with disengagement in human life, the industry is in obvious decline. The product is represented by new more advanced versions. Consumer demand for the old product wanes. As demand decreases, so too does production. The industry may either pass into posterity or restructure with new images and inventions, thereby giving birth to a new cycle. The automotive industry is at this phase.

Currently the robotics industry is in its development phase approaching nearly thirty years of evolution with a bright and prosperous future still ahead. On the other hand, the automotive industry is ap-

proaching 80 years of evolution, and having passed its peak appears to be evolving into a new configuration. It is worth noting that both public education and labor have been following life cycles commensurate with that of the automotive industry.

Conclusion

Because it is still small and in the early stages of development, the robotics industry provides education with a representation of the high tech industry in microcosm. Through it we can see the integration of several information technologies, i.e., the computer, fiber optics, video technologies, etc. The industry demands knowledge workers and that demand is expanding. The occupations that are emerging in response to the industry's needs call upon the new essential skills. And those individuals who have the requisite knowledge and skills, with the acknowledgement that they will need life long retooling can look forward to a productive place in our information society. As a new technology, as an information technology, as an integration of several technologies, and as a major growth industry, robotics can help lead the way for making connections between education, technology, and employment. Robotics can serve as a bridge to close the gap.

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